in the medium, and he has given expressions which assign to each part of the field a quantity of energy depending on the electromotive and magnetic intensities, and on the nature of the matter at that part in regard to its specific inductive capacity and magnetic permeability. These expressions account, as far as we know, for the whole energy. According to Maxwell's theory currents consist essentially in a certain distribution of energy in and around a conductor, accompanied by transformation and consequent movement of energy through the field.

Starting with Maxwell's theory we are naturally led to consider the problem, how does the energy about an electric current pass from point to point; that is, by what paths and according to what law does it travel from the part of the circuit where it is first recognisable as electric and magnetic to the parts where it is changed into heat or other forms.

The aim of this paper is to prove that there is a general law for the transfer of energy according to which it moves at any point perpendicularly to the plane containing the lines of electric and magnetic force, and that the amount crossing unit of area per second of this plane is equal to the product of the two intensities multiplied by the sine of the angle between them divided by 4π, while the direction of flow of energy is that in which a right-handed screw would move if turned round from the positive direction of the electromotive to the positive direction of the magnetic intensity. After the investigation of the general law several applications are given to show how the energy moves in the neighbourhood of various current-bearing circuits.

II. "Some Experiments on Metallic Reflection. IV. On the Amount of Light Reflected by Metallic Surfaces. II." By Sir JOHN CONROY, Bart., M.A. Communicated by Professor STOKES, Sec. R.S. Received December 15, 1883.

In a paper which Professor Stokes did me the honour of communicating to the Royal Society, and which appeared in the "Proceedings," vol. 35, p. 26, I gave an account of some experiments I had made on the amount of light reflected by polished metallic surfaces when ordinary unpolarised light was incident upon them.

The light of a paraffine lamp fell either directly, or after reflection from the metallic surface, on a photometer, and the readings were made by altering the distance at which another similar lamp had to be placed from the photometer in order to produce an equal illumination.

I have repeated the experiments with the steel and speculum metal

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mirrors with polarised light. The polish of the tin and silver mirrors being defective, it was not thought worth while to re-examine them.

The general arrangement of the apparatus remained the same; but in order to obtain a more intense light, a magic lantern (the one known as the "Sciopticon" being used) was substituted for the paraffine lamp carried by the goniometer. It was fixed on a wood stage fastened to a stout board about 80 centims. long; a screw, which passed through the board near one end and was fixed in a table, formed an axis about which the board could rotate; the goniometer was fixed to the board with its centre vertically over the axis of rotation.

A black card, with a slit 54 millims. by 4 millims., was placed in the slide-holder of the lantern, and a Nicol in the collimator tube of the goniometer, and the image of the slit focussed on the paper of the photometer.

The metal plates were clamped to the vertical stage, and their adjustment examined by placing a second, or analysing, Nicol in the path of the reflected light and crossing the Nicols, the former being placed with its principal section either in or perpendicular to the plane of incidence, and adjusting the stage screws till the light reflected from the plate was completely extinguished.

The experiments were made in the manner described in the former paper, the light being polarised in, or perpendicularly to, the plane of incidence by the Nicol. It was found that the illumination of the paper varied with the position of the Nicol, being always greatest when the light which fell on the paper was polarised in the plane of incidence.

Table I gives a series of observations made with the steel plate with light polarised in the plane of incidence. The numbers in the first column are the distances, in centimetres, of the sliding lamp from the photometer when the light from the lantern fell directly on the paper; and those in the third when the light was reflected by the mirror. The means of these observations are contained in the second and fourth columns, the angles of incidence in the fifth, and the ratios of the reflected to the incident light—the latter being taken as 100—in the sixth column.

As the intensity of light varies inversely as the square of the distance from the source, the percentage reflected by the plate is obtained by dividing the numbers contained in the second column by those in the fourth, squaring, and multiplying by 100.

Table II gives a similar series of measurements with the same plate and light polarised perpendicularly to the plane of incidence.

Three other similar series of observations were made, the actual determinations being about as concordant as those contained in the tables. The four sets of observations, and their means, are given in Tables III and IV.

Table I.

63·0 63·5 63·0 63·0					
	63·5	84·6 83·7 85·1 83·0	84·1	30°	57·01
63·6 64·0 64·0 63·9					
	63·8	80·8 81·7 81·7 80·8	81·2	40°	61·73
64·5 63·7 64·0 63·1					
	63·6	78·5 78·8 79·4 78·1	78·7	50°	65·31
63·8 62·5 63·5 63·9					
	63·6	77·1 75·7 77·7 76·4	76·7	55°	68·76
64·0 64·4 64·3 63·0					
	63·9	75·9 75·1 76·5 76·3	75·9	60°	70·88
63·4 64·2 63·8 64·2					
	63·8	73·3 71·7 73·4 72·1	72·6	65°	77·22
63·5 64·1 64·0 63·2					
	64·0	71·7 71·1 70·8 70·1	70·9	70°	81·48
64·5 64·0 64·5 64·4					
	64·1	70·3 69·2 70·4 69·8	69·9	75°	84·09
64·0 63·8 64·0 63·7					
	64·1	70·1 70·4 69·3 69·0	69·7	80°	84·58
65·0 64·7 64·7 63·1					

Table II.

79·2 77·3 78·8 77·1							
	77·7	112·0 110·0 112·0 109·0	110·7	....	30°	....	49·27
77·5 77·4 77·5 77·3							
	78·2	116·3 114·5 118·0 115·0	115·9	....	40°	....	45·53
80·0 78·6 79·3 78·3							
	78·8	124·5 124·0 124·0 123·1	123·9	....	50°	....	40·45
79·2 79·2 79·3 77·2							
	78·6	128·8 128·2 127·3 129·2	128·4	....	55°	....	37·47
79·2 78·6 79·0 77·5							
	80·0	136·5 132·8 135·7 131·9	134·2	....	60°	....	35·54
82·0 80·0 81·9 81·7							
	81·4	149·7 149·2 151·1 148·8	149·7	....	65°	....	29·57
81·5 81·8 81·7 80·5							
	81·7	163·8 161·1 162·3 157·7	161·2	....	70°	....	25·69
82·8 81·3 82·4 81·8							
	81·9	170·0 166·2 169·2 167·6	168·2	....	75°	....	23·71
80·6 81·9 82·5 82·2							
	82·7	161·0 160·8 163·0 160·4	161·3	....	80°	....	26·29
82·6 82·9 85·5 83·3							
	84·2	164·0 164·2 162·2 164·6	163·7	....	80°	....	26·46
85·5 84·1 86·0 84·0							

Table III.—Steel, with Light polarised in the plane of Incidence.

Angle of Incidence.	A.	B.	C.	D.	Mean.
30°	57·01	61·67	63·06	61·05	60·70
40	61·73	64·04	68·18	62·90	64·21
50	65·31	67·41	71·97	69·41	68·52
55	68·76	70·41			
60	70·88	74·55	77·96	74·31	74·42
65	77·22	76·02	81·40	74·83	77·37
70	81·48	80·77	85·22	81·57	82·26
75	84·09	84·92	90·32	84·71	86·01
80	84·58	86·34	91·55	89·01	87·87

Table IV.—Steel, with Light polarised perpendicularly to the Plane of Incidence.

Angle of Incidence.	A.	B.	C.	D.	Mean.
30°	49·27	50·53	53·67	47·28	50·19
40	45·53	45·39	49·79	44·40	46·28
50	40·45	41·24	43·47	38·78	40·98
55	37·47	37·34			
60	35·54	33·79	36·90	32·89	34·78
65	29·57	28·88	31·97	29·70	30·03
70	25·69	26·61	27·72	26·14	26·54
75	23·71	25·55	25·38	24·30	24·73
80	26·29	26·46	27·60	26·04	26·60

Similar measurements were made with the speculum metal mirror, and the results are given in Tables V and VI.

Table V.—Speculum Metal, with Light polarised in the Plane of Incidence.

Angle of Incidence.	A.	B.	C.	D.	Mean.
30°	64·58	64·09	63·37	66·18	64·55
40	67·76	68·22	65·14	69·86	67·74
50	72·65	72·23	69·04	71·90	71·45
60	76·63	78·65	77·57	77·95	77·70
65	79·65	79·68	79·44	81·26	80·01
70	83·09	81·25	84·94	83·90	83·29
75	82·94	84·20	86·93	88·01	85·52
80	87·52	86·78	90·96	89·72	88·74

Table VI.—Speculum metal, with Light polarised perpendicularly to the Plane of Incidence.

Angle of Incidence.	A.	B.	C.	D.	Mean.
30°	59·31	57·86	59·83	59·63	59·16
40	53·30	54·01	56·41	54·29	54·50
50	49·47	51·44	49·61	49·69	50·05
60	41·50	43·36	44·02	43·83	43·18
65	39·95	39·12	40·50	40·85	40·10
70	38·27	35·84	37·42	38·29	37·45
75	36·20	34·45	36·84	35·88	35·84
80	40·51	38·67	41·22	41·15	40·39

The principal incidences and azimuths for both plates were determined in the manner described in "Proc. Roy. Soc.," vol. 31, p. 486, and vol. 35, p. 32. Four observations were made in each position of the retarding plate, two with the principal section of the polarising Nicol on the right, and two with it on the left of the plane of incidence. The means of the several sets of eight observations are given in Table VII; the probable error of the mean result, calculated by the ordinary formula $0{\cdot}6745\sqrt{\frac{\Sigma\Delta^2}{n(n-1)}}$ is also given.

Table VII.

	Principal incidence.	Mean.	Principal incidence.	Mean.
Steel..........	76° 05′		28° 31′	
	76 17	Prob. error.	28 33	Prob. error.
	76 17	76° 20′ ± 5′	28 28	28° 29′ ± 1′.
	76 42		28 26	
Speculum metal..	74 48		33 28	
	75 23		33 09	
	76 07		32 32	
	75 38	75 31 ± 7′	32 40	33 02 ± 6′.
	—		—	
	75 39		33 23	
	75 32		33 01	

A beam of ordinary light being equivalent to two beams of half its intensity polarised at right angles to each other, the percentage of light reflected by the plates, if ordinary unpolarised light were incident upon them, is given by half the sum of the intensities of the light polarised in, and perpendicular to, the planes of incidence.

In Table VIII the numbers obtained in this way are given in the 2nd and 5th columns, the values as determined by the experiments described in the paper already referred to in the 3rd and 6th columns, and in the 4th and 7th columns the results calculated out, as described in a subsequent part of the present paper, from the measurements made with polarised light.

Table VIII.

Steel.				Speculum metal.		
Observations made with polarised light. $\frac{J^2+I^2}{2}$		Observations made with ordinary light. $\frac{rJ^2+I^2}{r+1}$		Observations made with polarised light. $\frac{J^2+I^2}{2}$	Observations made with ordinary light. $\frac{rJ^2+I^2}{r+1}$	
		Observed.	Calculated.		Observed.	Calculated.
30°	55·44	54·93	56·62	61·85	66·87	62 39
40	55·24	55·62	57·26	61·12	67·26	62·61
50	54·75	56·74	57·84	60·75	67·26	63·15
60	54·60	57·63	59·04	60·44	66·32	64·31
65	53·70	58·37	59·0	60·05	66·53	64·53
70	54·40	58·09	60·65	60·37	67·65	65·51
75	55·37	58·69	62·33	60·68	67·43	66·22
80	57·23	63·56	64·10	64·56	70·17	69·98

In addition to the actual numerical differences between the values, the two sets of observations appear to differ fundamentally, for whilst the numbers in the second and fifth columns diminish slightly, and then increase again, as the angle of incidence increases, those in the third and sixth increase with the angle, a result that, as was pointed out in the former paper, is not in accordance with either theory, or previous observations, and which, as was stated in the paper, if erroneous, must have been caused by some defect in the method employed, and therefore common to all the determinations.

Further consideration showed that such was really the case, and that the defect in the method was the one pointed out by Professor Stokes in the note appended by him to the paper ("Proc. Roy. Soc.," vol. 35, p. 39). As has already been stated, the apparent brightness of the paper varied with the polarisation of the incident light, or, in other words, the amount of light irregularly reflected, or diffused, by the paper was different for light polarised in, or perpendicularly to, the plane of incidence. The light being incident upon the paper at an angle of about 30°, whilst the line of sight formed an angle of about 60° with the normal, no regularly reflected light could reach the observer.

The terminal faces of the polarising Nicol were perpendicular to its long diameter, and it was of a nearly circular section, so that the amount of light transmitted by the Nicol must have been very nearly, if not absolutely, the same in both positions.

Table IX gives observations made to determine the amount of illumination in both cases, the numbers in the first column being the distances at which the sliding lamp had to be placed when the light was polarised in the plane of incidence, and those in the second, when it was polarised in a plane at right angles to this; each determination being the mean of four observations.

Table IX.

	70·9	....	85·3
	70·0	....	90·4
	68·8	....	86·9
	70·0	....	88·8
Mean....	69·9	....	87·8

Calling the light diffused by the paper when the incident light was polarised in the plane of incidence 100, it would appear that when the light was polarised perpendicularly to that plane only about 63 per cent. of the light reached the observer.

The very considerable difference in the amount of light diffused in the two cases seems the more remarkable, as previous to the publication of the former paper the illuminated surfaces of the photometer were examined with a bi-quartz, and although they showed traces of polarisation it was only, apparently at least, to a very inconsiderable extent.

This experiment has been recently repeated, and with the same result; the lamp light diffused by the paper of the photometer showing hardly any, if any, traces of polarisation, whilst that reflected obliquely from the blackened surface of the board along which the lamp was arranged to slide, when examined in the same way, was seen to be strongly polarised.*

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* [Of the light falling on the paper, a considerable part would be reflected at various depths before it had lost, through the various irregular reflections and refractions, all traces of its original polarisation, and consequently light derived from that which was originally polarised in the plane of incidence would be more copiously reflected than light derived from that which had been polarised in a perpendicular plane. But the light so reflected would have to make its way among the fibres of the paper, especially as the angle of emergence was considerable, and in so doing would be pretty well depolarised by the irregular reflections and refractions which it would have to undergo. This accounts for the circumstance

Owing to the unequal reflection of light polarised in and perpendicularly to the plane of incidence, the experimental results contained in the paper published in the "Proc. Roy. Soc." vol. 35, p. 26, cannot be the true values of the amount of light reflected by the mirrors.

The lamp light which was incident upon the mirrors, being equivalent to two beams of half its intensity polarised in and perpendicularly to the plane of incidence, and light polarised in and perpendicularly to this plane being unequally diffused by the paper, as well as unequally reflected by the mirrors, the observed intensity must, as Professor Stokes pointed out, be $\frac{rJ^2+I^2}{r+1}$, and not $\frac{J^2+I^2}{2}$.

Assuming the values of J^2 and I^2 found from the determinations with polarised light, and the value of r from the measurements contained in Table IX, the value of $\frac{rJ^2+I^2}{r+1}$ for the two mirrors at different incidences were calculated out,* and the numbers thus obtained are given in the fourth and seventh columns of Table VIII.

In the case of the steel mirror the observed and calculated numbers agree tolerably, as well, perhaps, as could have been expected, recollecting the nature of the determinations, but with the speculum metal mirror the results are discordant, the calculated results being in all cases too low. The observations with unpolarised light were made immediately after the mirror had been polished, whilst an interval of several months elapsed before those with polarised light were finished. Although the mirror was kept in a dry warm room, and in a closed case containing lime, its surface was usually found to be covered with a slight film; this was readily removed by rubbing it gently for a few seconds with a piece of wash-leather, and the surface then appeared perfectly bright.

After the conclusion of the experiments with polarised light, the photometer was rearranged in its original form, and three observations were made of the amount of unpolarised light reflected by the mirror at an angle of 30° in order to ascertain whether the reflective power

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that the illumination was so different that was produced by light polarised in the two ways, even though the polarisation of the light coming from the paper was very feeble when the light incident was common light. I overlooked this when I proposed ("Proc. Roy. Soc.," vol. 35, p. 39) to measure r by measuring the polarisation of the light coming in this case from the paper, and regarded r as only "a little" greater than J on the strength of the author's assurance that the polarisation was so slight.—G. G. S.]

* The actual calculations were made with the equivalent formula $\frac{J^2+rI^2}{100+r}$, in which $r=63{\cdot}38$.

of the mirror had been diminished by the formation and removal of this film on several occasions.

	Light reflected, per cent.
	62·42
	63·04
	63·30
Mean......	62·92

The mean of these three observations agrees very fairly with the value deduced from the observations with polarised light, and it therefore seems probable that the differences between the numbers contained in the sixth and seventh columns of Table VIII are due to an alteration in the surface of the mirror, analogous possibly to the surface changes that Seebeck found with freshly polished transparent bodies.

The values obtained for the principal incidence, and principal azimuth, with the freshly polished mirror, and with the same mirror at the conclusion of the experiments with polarised light, differ but little from each other, as is shown in Table VII. The first four observations with the speculum metal mirror were made at the end of the experiments, and their means 75° 35′′ and 33° 12′ agree very closely with the means of the last two observations 75° 29′ and 32° 57′ made with the freshly polished mirror.

The amount of light which, according to Cauchy's theory, ought to have been reflected by the mirrors was calculated out by the formulæ—

$$\mathrm{J}^2=\frac{\theta^2+\cos^2 i-2\theta\cos\epsilon\cos i}{\theta^2+\cos^2 i+2\theta\cos\epsilon\cos i}\text{ and }\mathrm{I}^2=\frac{\theta^2\cos^2 i+1-2\theta\cos\epsilon\cos i}{\theta^2\cos^2 i+1+2\theta\cos\epsilon\cos i},$$

and the results set forth in Tables X and XI.

Table X.—Amount of Light reflected by Steel Mirror.

	Observed.		Calculated.	
	J^2.	I^2.	J^2.	I^2.
30°	60·70	50·19	63·17	54·95
40	64·21	46·28	66·44	51·31
50	68·52	40·98	70·80	42·09
60	74·42	34·78	76·72	39·24
65	77·37	30·03	79·52	35·32
70	82·26	26·54	83·04	31·62
75	86·01	24·73	86·85	29·46
80	87·87	26·60	90·97	32·39

Table XI.—Amount of Light reflected by Speculum Metal Mirror.

	Observed.		Calculated.	
	J^2.	I^2.	J^2.	I^2.
30°	64·55	59·16	69·78	62·82
40	67·74	54·50	72·53	59·74
50	71·45	50·05	76·18	55·37
60	77·70	43·18	80·77	49·59
65	80·01	40·10	83·42	46·38
70	83·29	37·45	86·32	43·53
75	85·52	35·84	89·44	42·29
80	88·74	40·39	92·77	45·88

As far as the general character of the phenomena the agreement is complete and in accordance with the observations of M. Jamin, but the actual values of the observed intensities always fall short of the calculated intensities, the difference being least with the steel mirror.

The probable errors of the values of the principal incidences and azimuths having been ascertained, the theoretical intensities of the light reflected at an angle of 30° were calculated for the two values obtained by adding and subtracting these sums from the means. The probable errors of the photometric measurements for the same angle were also determined, and Table XII gives the values thus obtained.

Table XII.

Steel Mirror.

	Observed.		Calculated.	
	J^2.	I^2.	J^2.	I^2.
30°	61·57	51·09	63·38	55·17
	59·83	49·29	62·97	54·72

Speculum Metal Mirror.

30°	64·95	59·60	70·24	63·35
	64·15	58·72	69·37	62·37

These numbers seem to show that the differences between the calculated and observed results are not merely due to errors of observation, a conclusion that is rendered the more probable by the fact that the difference is always in the same direction.

The polish of the mirrors was examined at the end of the experiments by the method suggested by Professor Stokes, and described in the paper already referred to; both the mirrors stood the test satisfactorily, the polish of the steel being very slightly the best.

These experiments appear to show that the generally received formulæ for metallic reflection are approximately correct, but that the actual intensity of the reflected light is always less than the theoretical intensity, and that therefore, unless this be due to defects in the metallic surfaces, the formulæ do not completely express the laws of metallic reflection. If, as appears to be the case, a change in the reflective power of a plate can occur without any change in the values of the principal incidence and azimuth, it is necessary to regard the formulæ as only approximately true, and there is additional reason for thinking that, as Professor Stokes has suggested, three constants are required to define a metal optically.

I hope hereafter to determine the amount of light reflected by films of silver chemically deposited on glass, and also to make some determinations of the amount of radiant energy reflected by metallic surfaces at various angles, the experiments of MM. de la Prevostaye and Desains on this point having been but few in number.

III. "Extracts from a Report on the Volcanic Eruption in Sunda Strait by Commander the Honourable F. C. P. VEREKER, H.M.S. 'Magpie,' dated Singapore, October 22, 1883." Communicated by Sir FREDERICK EVANS, K.C.B., F.R.S. Received December 15, 1883.

[PLATES 2, 3.]

* * * On the 18th instant I entered Sunda Strait, passing east of Thwart-way Island. This island had been reported to be split by the eruption into several portions. This is incorrect.

The island is intersected by low valleys in several places, these being covered with tall trees did not show so prominently formerly as they do now. The whole of the vegetation having been swept away by the tidal wave the island at a short distance off is apparently divided, the low necks joining the higher portions being only visible on close approach.

The surface of the Strait in this neighbourhood is covered with extensive fields of floating pumice stone, often in one to two foot cubes, through which the ship easily forced her way.

* * * * * *

I inclose sketches which I trust will convey the general appearance better than a written description. The whole of the neighbourhood is covered with greenish-yellow mud, and all traces of vegetation are everywhere destroyed.